MONITORING COASTAL SALT MARSHES IN THE LAKE CLARK AND KATMAI NATIONAL PARKLANDS OF THE SOUTHWEST ALASKA NETWORK

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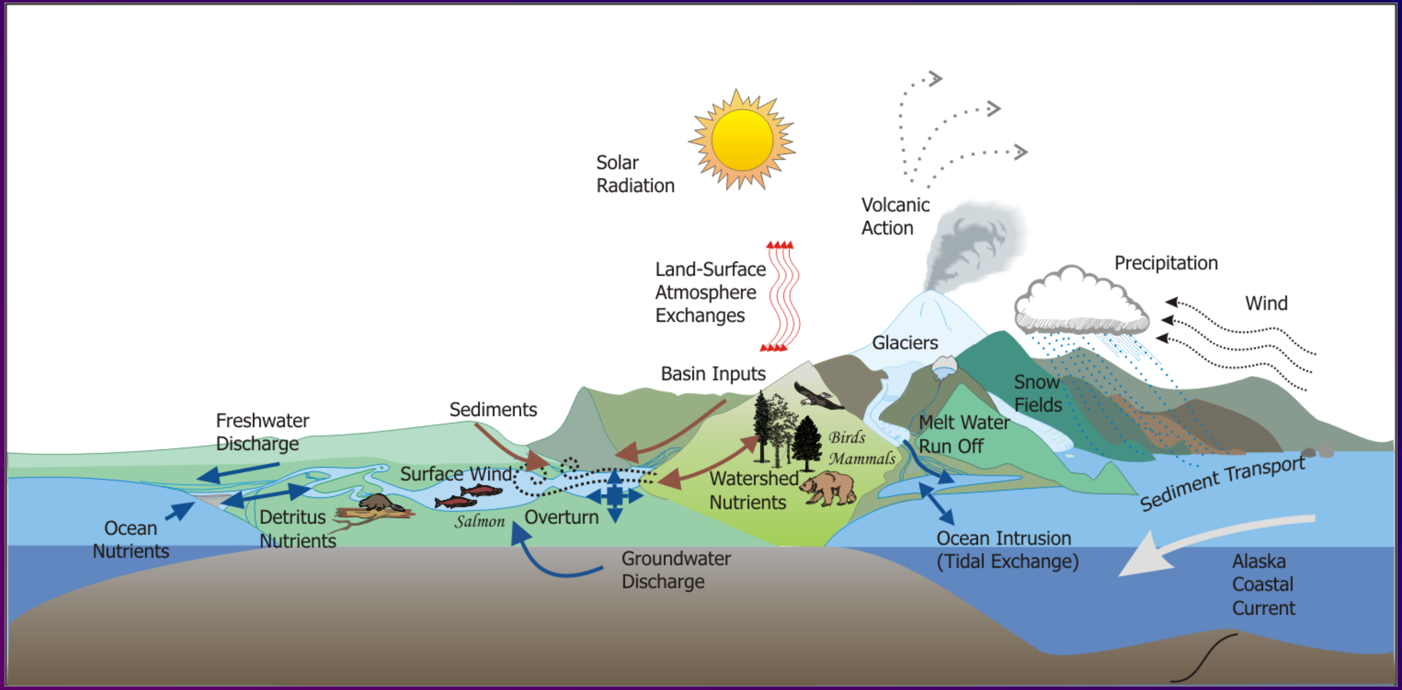
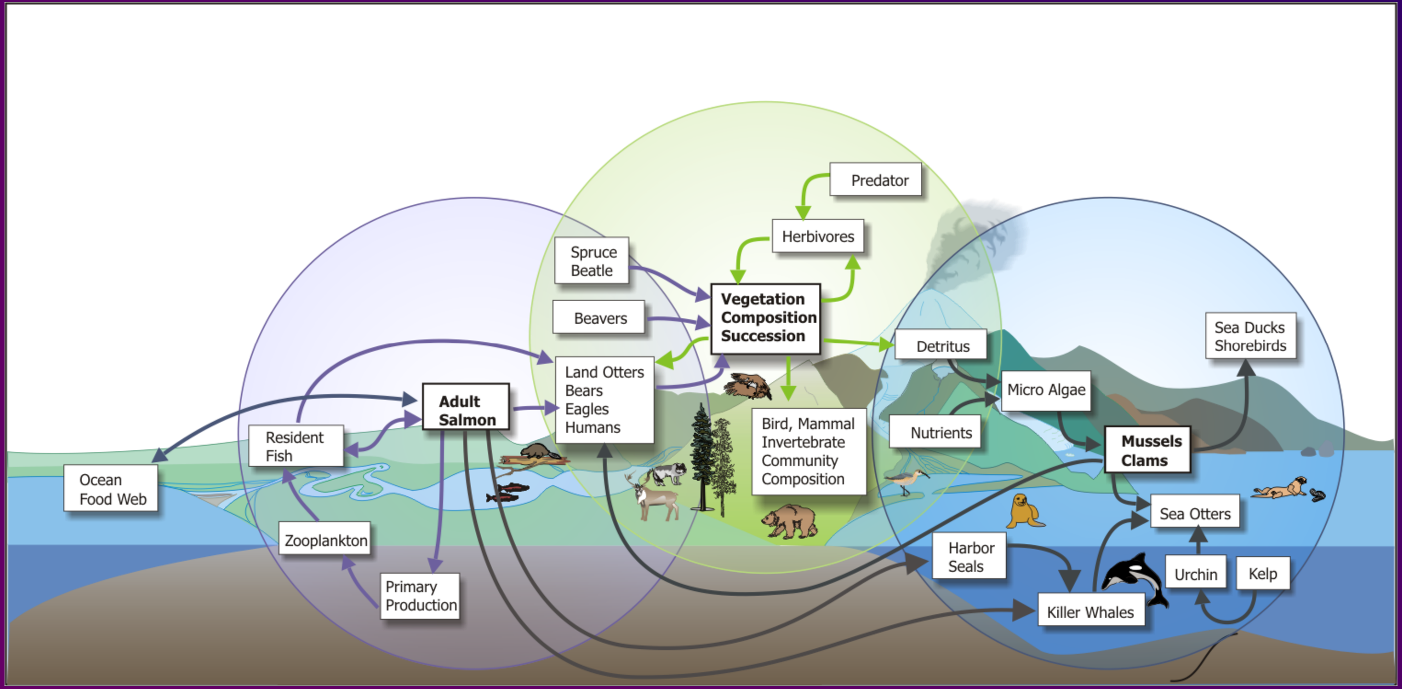
Need for Monitoring

- Sheltered salt marshes and tidal flats in SWAN are important ecological features of the coastlines because they support productive, high-quality forage that serves as important feeding and resting areas for brown bears (*Ursus arctos horribilis*), waterfowl, and shorebirds (Bennett et al. 2005).
- salt marshes have been identified as a “vital sign” for monitoring in the SWAN network.
- As a basis for establishing a long-term monitoring program for the salt marshes of Lake Clark National Park and Preserve (LACL) and Katmai National Park and Preserve (KATM), this study plan identifies the components of a comprehensive monitoring program and the strategies that are needed to develop a protocol and standard operating procedures (SOPs) consistent with other national efforts of the National Park Service.

A 1954 aerial photo of the mouth of Little Glacier Creek entering northern Chinitna Bay

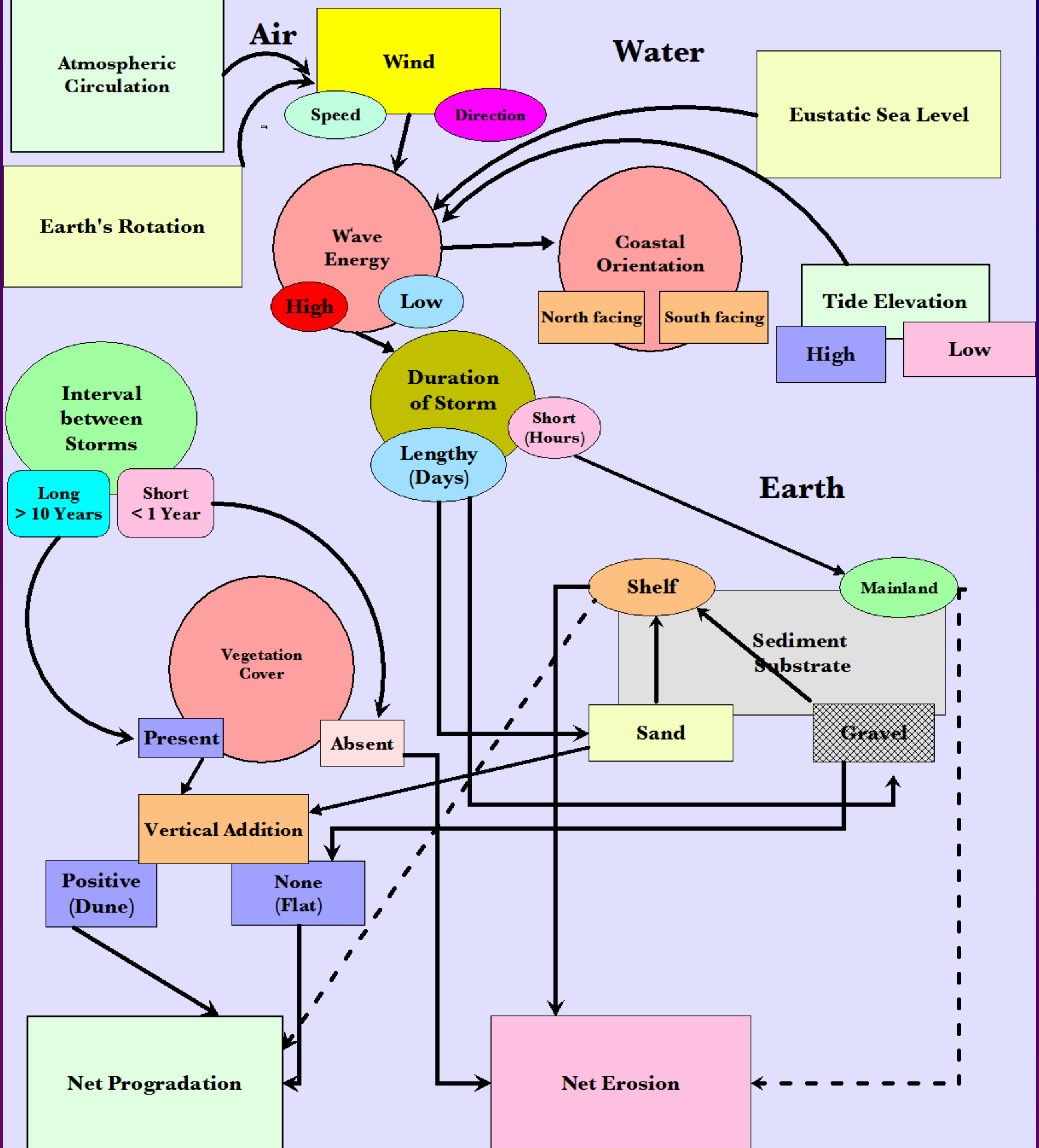

2004 Ikonos image


Solar Radiation
Volcanic Action
Land-Surface Atmosphere Exchanges
Precipitation
Wind
Glaciers
Basin Inputs
Snow Fields
Sediments
Freshwater Discharge
Melt Water Run Off
Birds
Mammals
Surface Wind
Watershed Nutrients
Sediment Transport
Ocean Nutrients
Detritus Nutrients
Salmon
Overturn
Ocean Intrusion (Tidal Exchange)
Groundwater Discharge
Alaska Coastal Current


Predator
Herbivores
Spruce Beatle
Vegetation Composition Succession
Beavers
Detritus
Land Otters Bears Eagles Humans
Micro Algae
Sea Ducks Shorebirds
Adult Salmon
Resident Fish
Bird, Mammal Invertebrate Community Composition
Nutrients
Mussels Clams
Ocean Food Web
Sea Otters
Zooplankton
Harbor Seals
Urchin
Kelp
Primary Production
Killer Whales

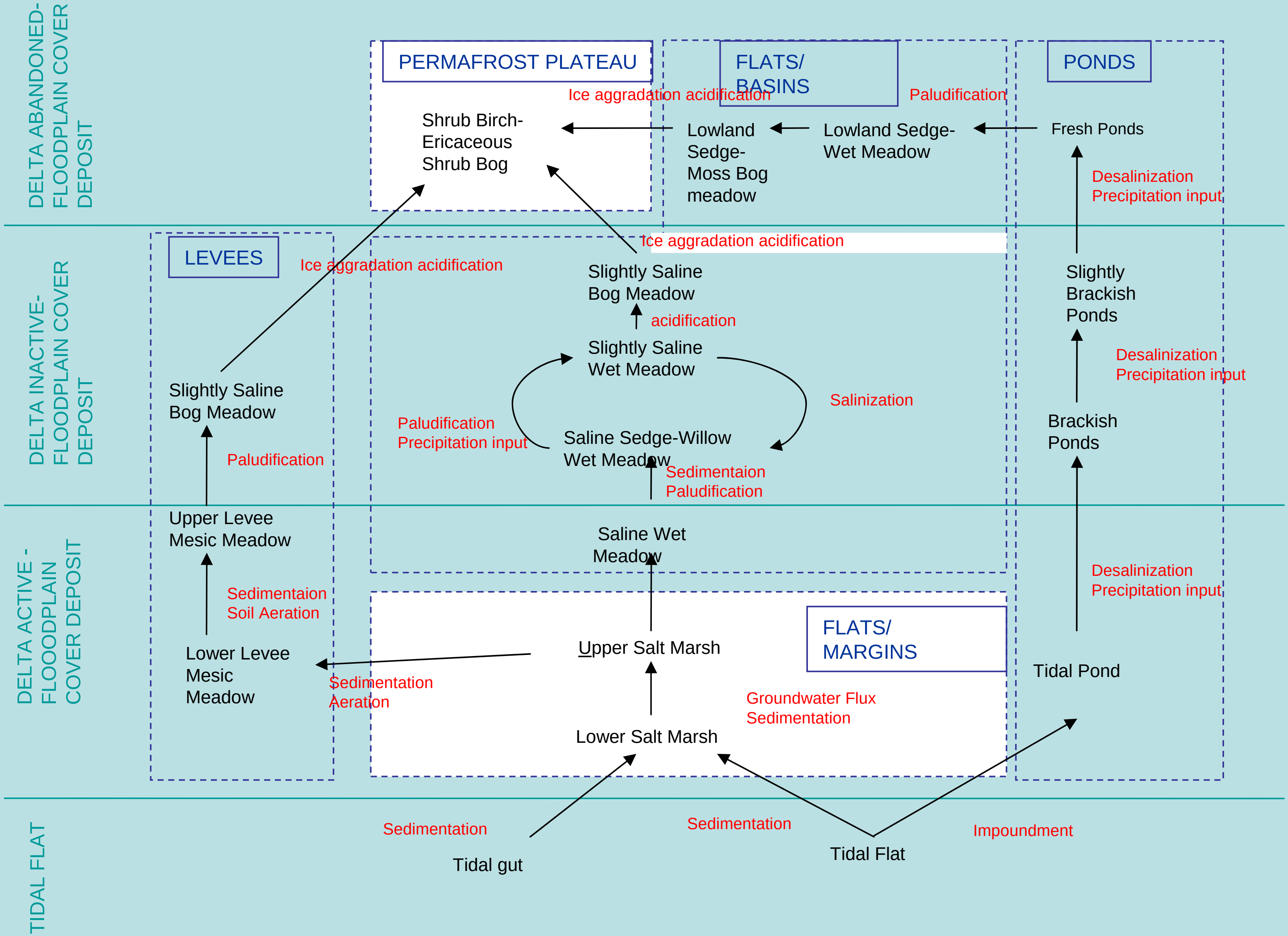
KEY PROCESSES

- Tectonics
- Relative Sea level change
- Storm Frequency
- Storm surge height
- Sedimentation (nutrient input, disturbance)
- Foreshore erosion and scouring
- Salinization inshore
- Paludification (OC accumulation and acidification)
- Surface water impoundment (behind levies)
- Vegetation change
- Grazing levels
- Wildlife Use



Owen Mason's Arctic Coastal Model

PATHWAYS OF ECOSYSTEM EVOLUTION, TUTAKOKE STUDY AREA



Monitoring Objectives

- **Detect change in salt-marsh topography through ground-based measurements;**
- **Monitor tidal fluctuations, storm surges, and water levels in tidal ponds with submersible water-level recorders;**
- **Detect change in sedimentation rates, pore-water salinity, and pH across the topographic gradient through ground-based measurements’**
- **Determine changes in the abundance and distribution of plant community types across the gradient, both as point-intercept plots along transects and photo points.**
- **Detect decadal changes in the aerial extent of salt marshes, the abundance of salt marsh communities, and surface water changes in tidal guts and ponds through remote sensing.**
- **Sample in a logistically practical, safe, and cost-effective manner.**

Sampling Designs – Random/Systematic

ADVANTAGES:

systematic or random sampling design is desirable for obtaining an unbiased estimate of ecosystem properties across an entire region of interest

DISADVANTAGES:

- **Inefficient at sampling uncommon ecosystems of high interest;**
- **Undesirable for linking ecosystem properties to remote sensing data because some plots crossing ecosystem boundaries;**
- **Inefficient at sampling the end ranges in property gradients of needed to model ecological responses to environmental change**
- **Impractical for accessing remote coastal areas with frequent hazardous weather conditions;**
- **Focuses on producing region-wide estimates that are of little value for evaluating ecological change because properties are averaged over a wide-range of ecological conditions that targets the most common ecosystem types.**

Sampling Designs - Stratified

ADVANTAGES:

Stratified systematic sampling improve sample distribution for uncommon types

DISADVANTAGES

- **reliable information is needed for *a-priori* stratification;**
- **the design reduces the ability to provide unbiased estimates of ecosystem properties across the region of interest.**

Judgmental Sampling

ADVANTAGES:

- Ensures adequate sampling of uncommon habitats;
- Targets sampling across the entire range of ecological conditions;
- Efficient at stratifying by ecosystem type;
- Can focus on more readily accessible areas;

DISADVANTAGES:

Introduces substantial bias into estimates of ecosystem properties

STRATIFIED, SYSTEMATIC WITH ADDITIONAL JUDGEMENTAL PLOTS

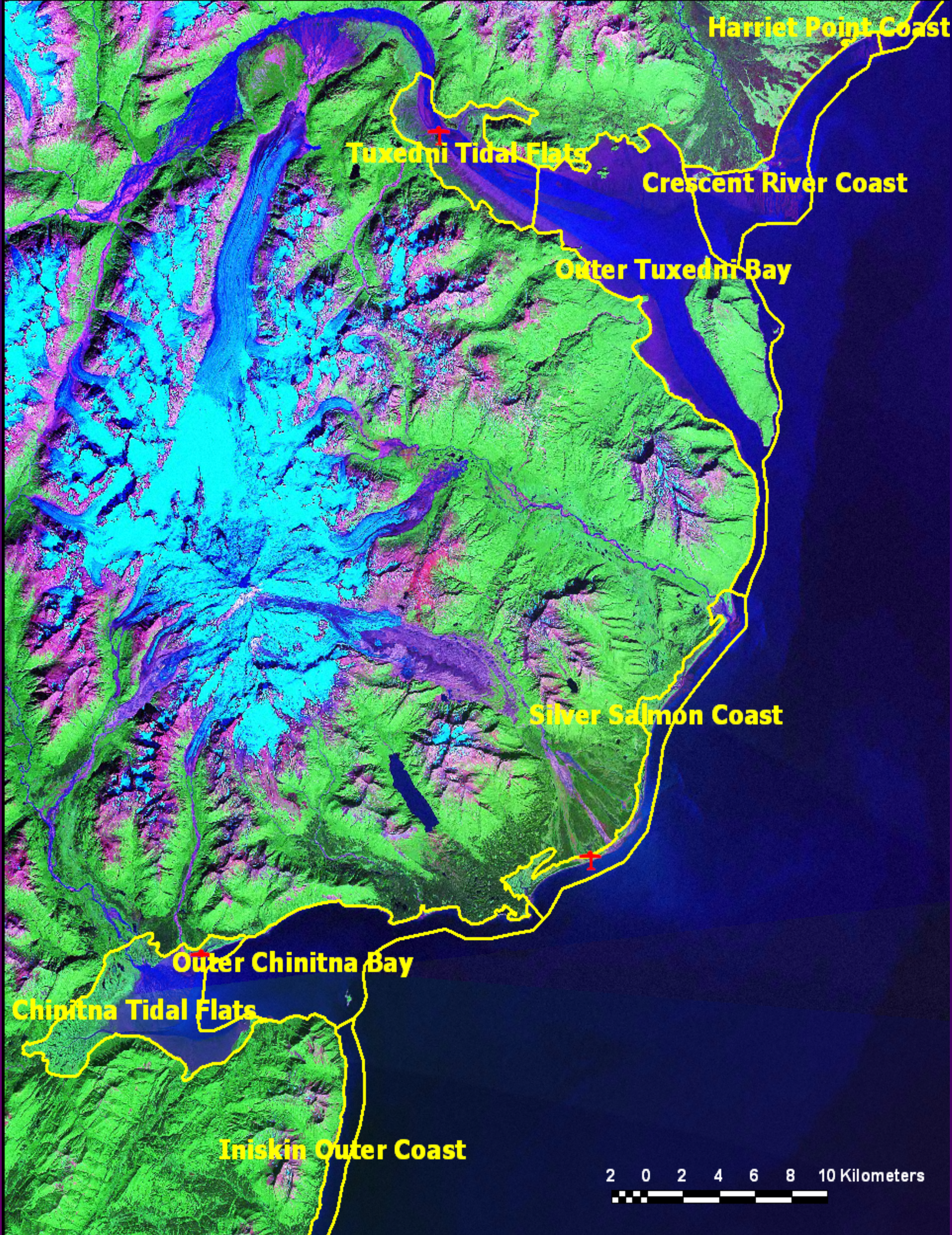
1) subdivide the coastal ecoregion into landscape-level units (subsections) that represent contiguous portions of the coast with similar repeating geomorphic and vegetative characteristics
2) Select two coastal types: salt marshes and delta complexes
3) the sampling could be done systematically along 3–4 gradient-oriented transects (perpendicular to the coast) at uniform distances along the coast to reduce the bias in plot allocation.
4) plots would be systematically distributed (every 50 or 100 m) along the transects so that the sampling provides a representative and unbiased sample across the subsections.
5) additional samples could be established judgmentally in uncommon ecosystem types, or at sites with human-related impacts (e.g., ORV trails, debris, visible oil), to increase the sample size for unusual features.
6) sampling of biophysical characteristics will be co-located to allow analysis of relationships among biological and physical variables.

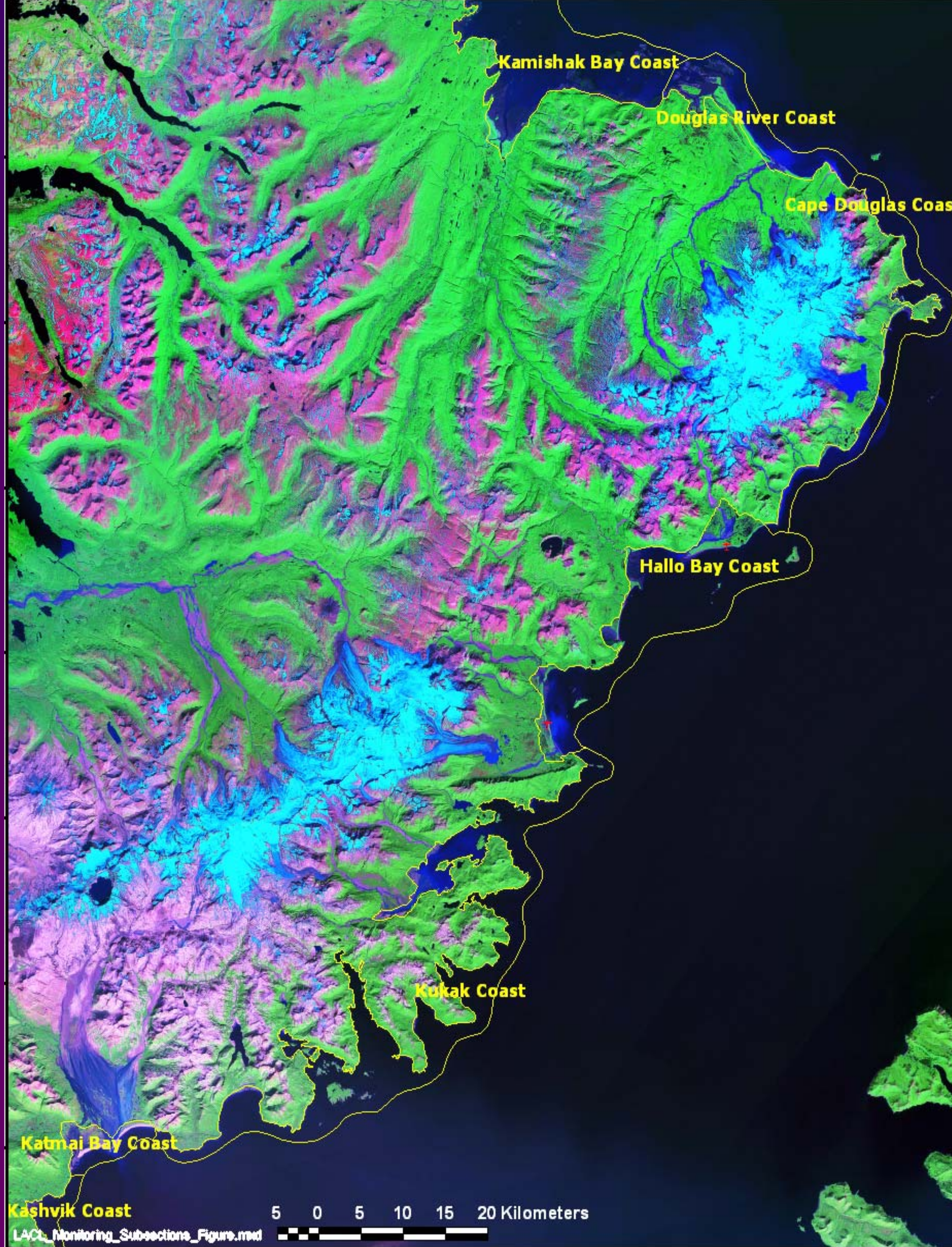
SAMPLING DESIGN

- **Stratify by coastal type**
  - **Replicate 2 sites within two coastal types (salt marsh vs sandy delta/dune/tidal flat)**
- **Establish equally distributed transects across topo gradient**
  - **Replicate each transect 3 times within site**
- **Each transect has 6-10 systematically distributed monitoring plots,**
- **Additional plots established in uncommon vegetation types.**
- **Total Sampling Effort**
  - **2 coastal types x 2 sites x 3 transects = 12 transects**
  - **12 transects X 10 Plots = Total ~ 120 plots, 30-40 plots/site**
  - **2 crews X 2 people can do ~1 site in 6 days.**
- **Sampling Schedule**
  - **Monitor 2 sites, 6 transects, 60-80 plots in 12 days per year,**
  - **Monitor every 5 years for first 10 years, every 10 years thereafter,**

Subsection Stratification

Coastal Typed:
- **Slat marsh/tidal flat**
- **Sandy delta/dune**
- **Gravel Beaches**
- **Bedrock**




Kamishak Bay Coast
Douglas River Coast
Cape Douglas Coast
Hallo Bay Coast
Kukak Coast
Katmai Bay Coast
Kashvik Coast
5 0 5 10 15 20 Kilometers
LACL_Monitoring_Subsections_Figure.mxd

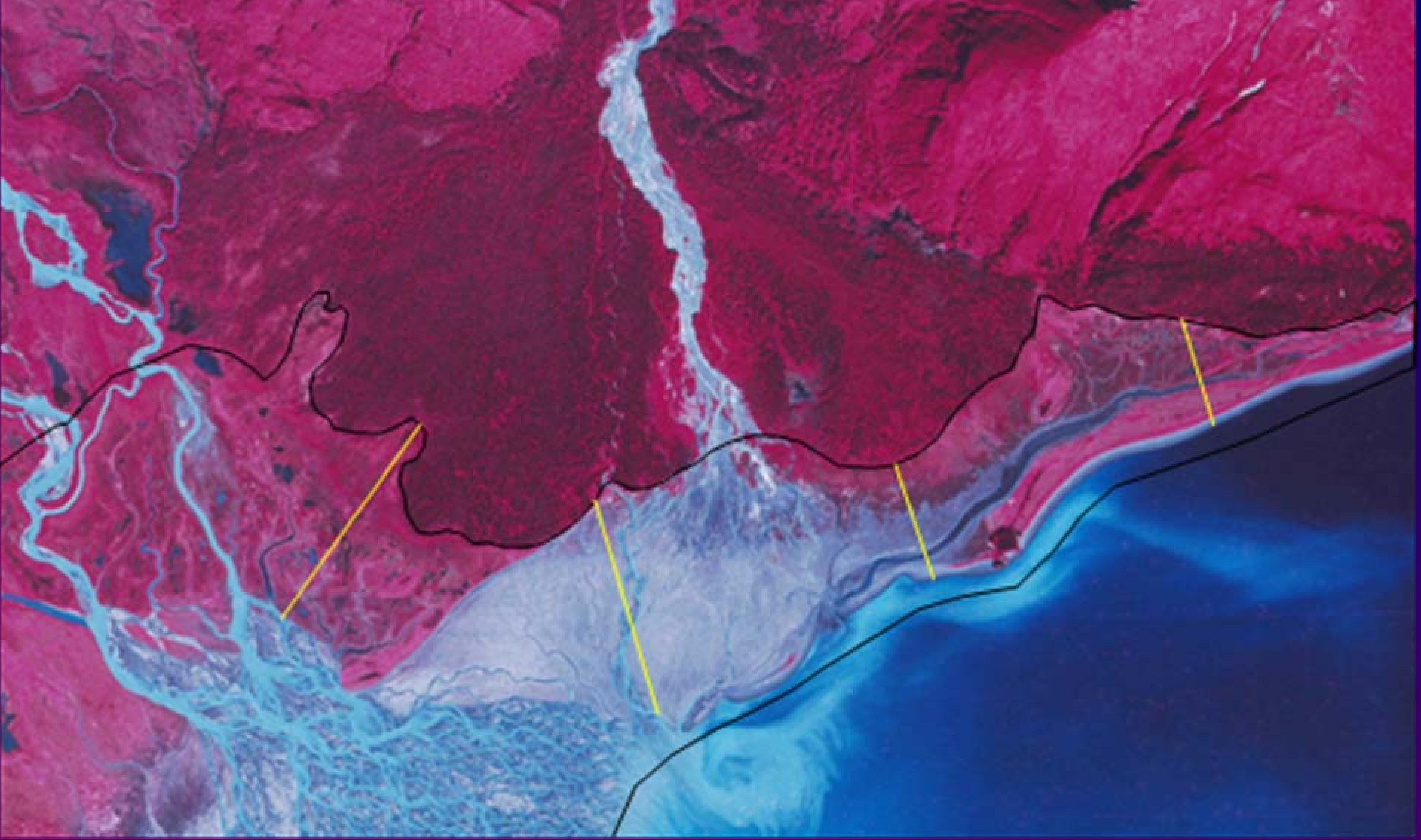


Figure 3. Potential layout of systematically distributed sampling transects (yellow) in the Chinitna Tidal Flat subsection within Lake Clark National Park and Preserve. The black line delineates the coastal subsection and upward limits of salt-affected habitats.

Coastal Monitoring Parameters

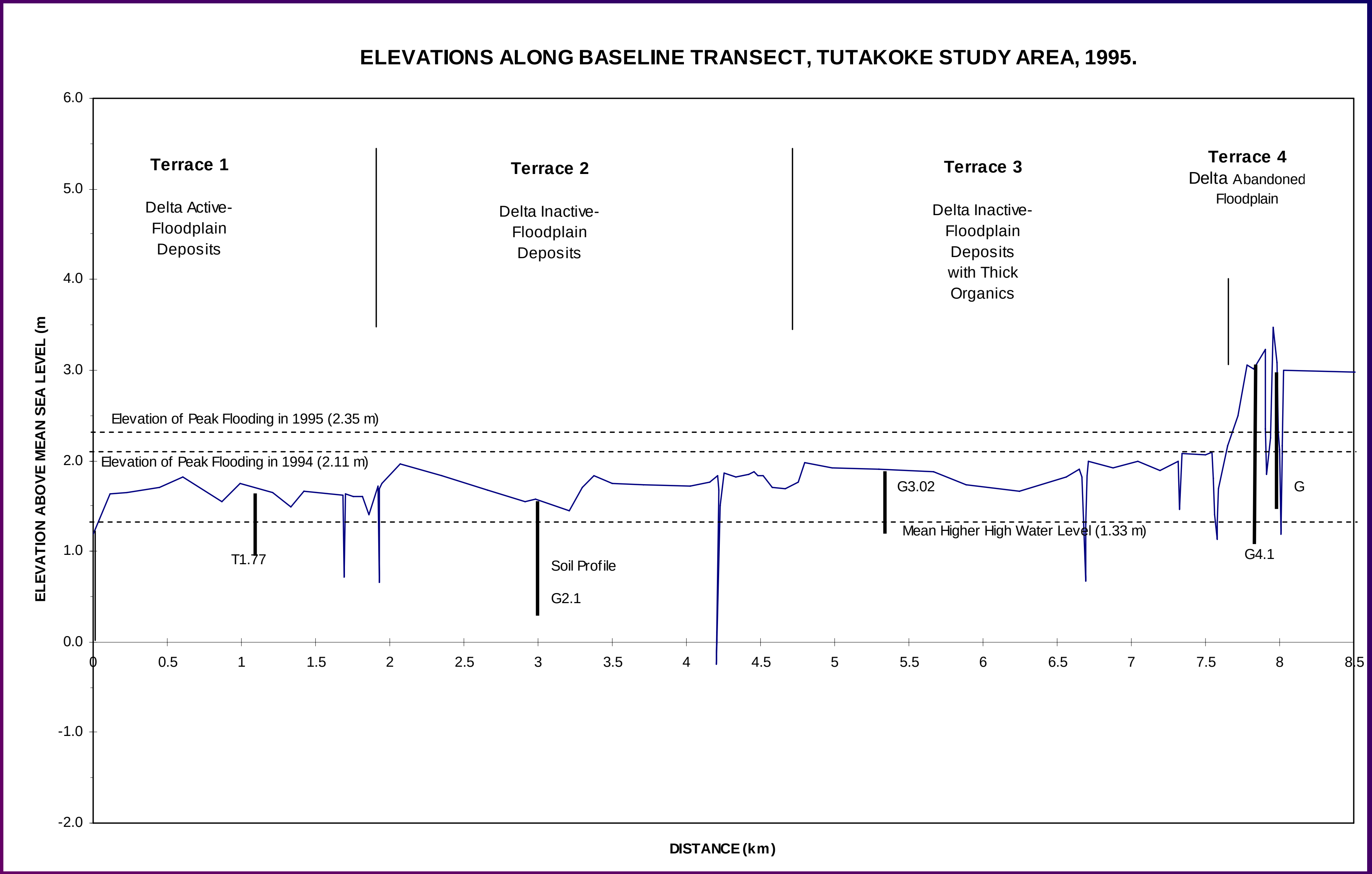
Physical
Topography/Bathymetry (T)
Shoreline position (R)
Waterbody coverage (R)
Water level/Storms (P)
Sedimentation rates (P)
Chemical
Water pH (P)
Water Salinity (P)

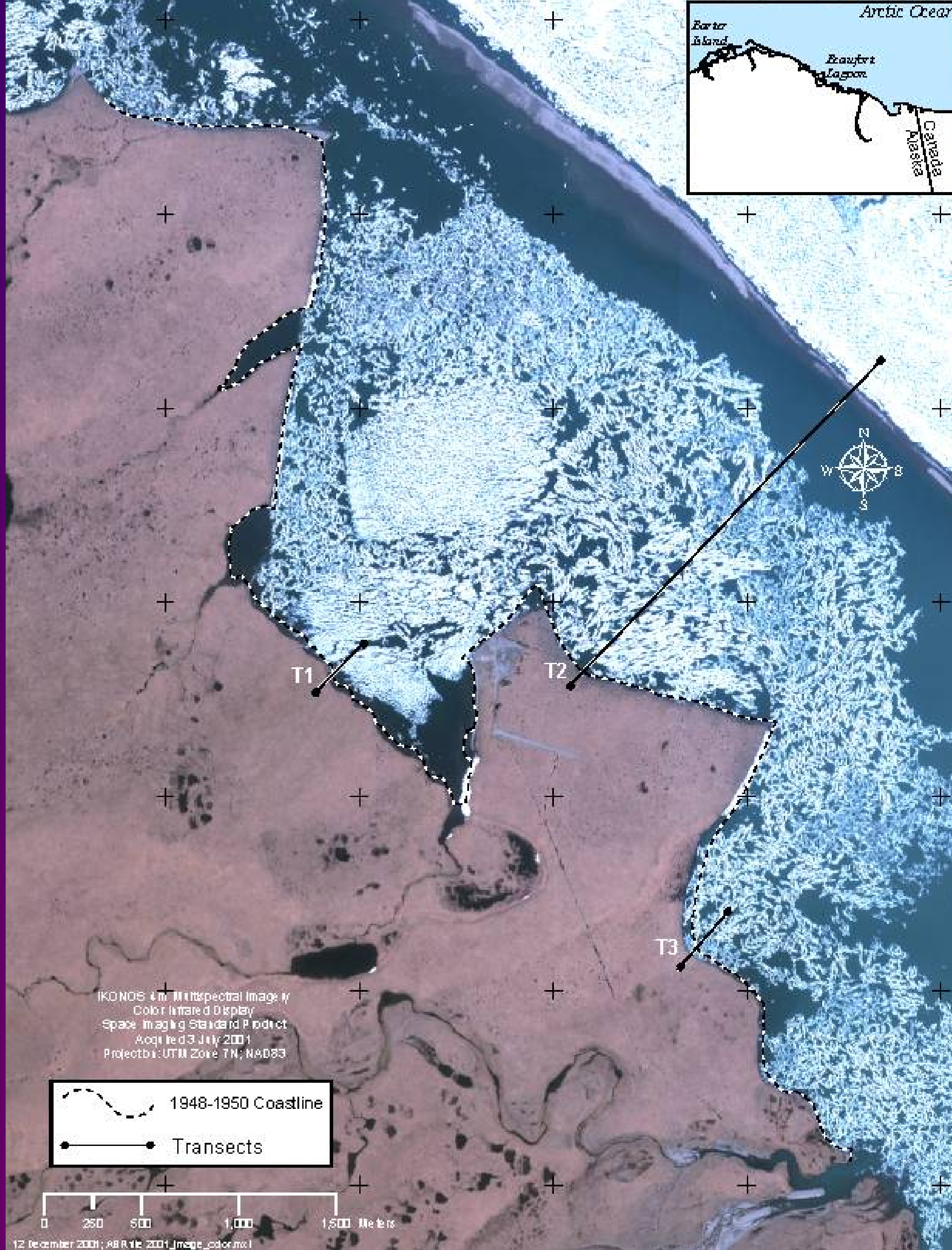
Biological
Acreage of ecosystem type (R)
Plant cover and frequency (P)
Plant community composition (P)
Frequency of indicator/exotic species (P)
Herbivory from bears and geese (P)
Woody debris (tidally-deposited) (T)
Anthropogenic
Trash (T)
Camp-sites and trail (GM)

R= remote sensing, T = transect, P = plot, GM = GPS ground mapping

Remote Sensing

- **Pilot-scale analysis of a time-series of historical aerial photography**
- **Aerial photography collected from the 1950s (1:40,000) and 1980's (1:63,000) will be georectified to the new IKONOS imagery**
- **Two study sites (Chinitna Bay and Silver Salmon).**
- **Point-sampling method will be used to document change at 200 points within the same map area.**
- **Test what types of vegetation change (hierarchical levels of community classification) can be detected**


ELEVATIONS ALONG BASELINE TRANSECT, TUTAKOKE STUDY AREA, 1995.
Terrace 1
Delta Active-Floodplain Deposits
Terrace 2
Delta Inactive-Floodplain Deposits
Terrace 3
Delta Inactive-Floodplain Deposits with Thick Organics
Terrace 4
Delta Abandoned Floodplain
Elevation of Peak Flooding in 1995 (2.35 m)
Elevation of Peak Flooding in 1994 (2.11 m)
Mean Higher High Water Level (1.33 m)
T1.77
Soil Profile
G2.1
G3.02
G4.1
G
ELEVATION ABOVE MEAN SEA LEVEL (m
DISTANCE (km)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5


Arctic Ocean
Canada
Alaska
N
W
E
S
T1
T2
T3
IKONOS 4m Multispectral Imagery
Color Infrared Display
Space Imaging Standard Product
Acquired 3 July 2001
Projection: UTM Zone 7N; NAD83
1948-1950 Coastline
Transects
0
250
500
1,000
1,500 Meters

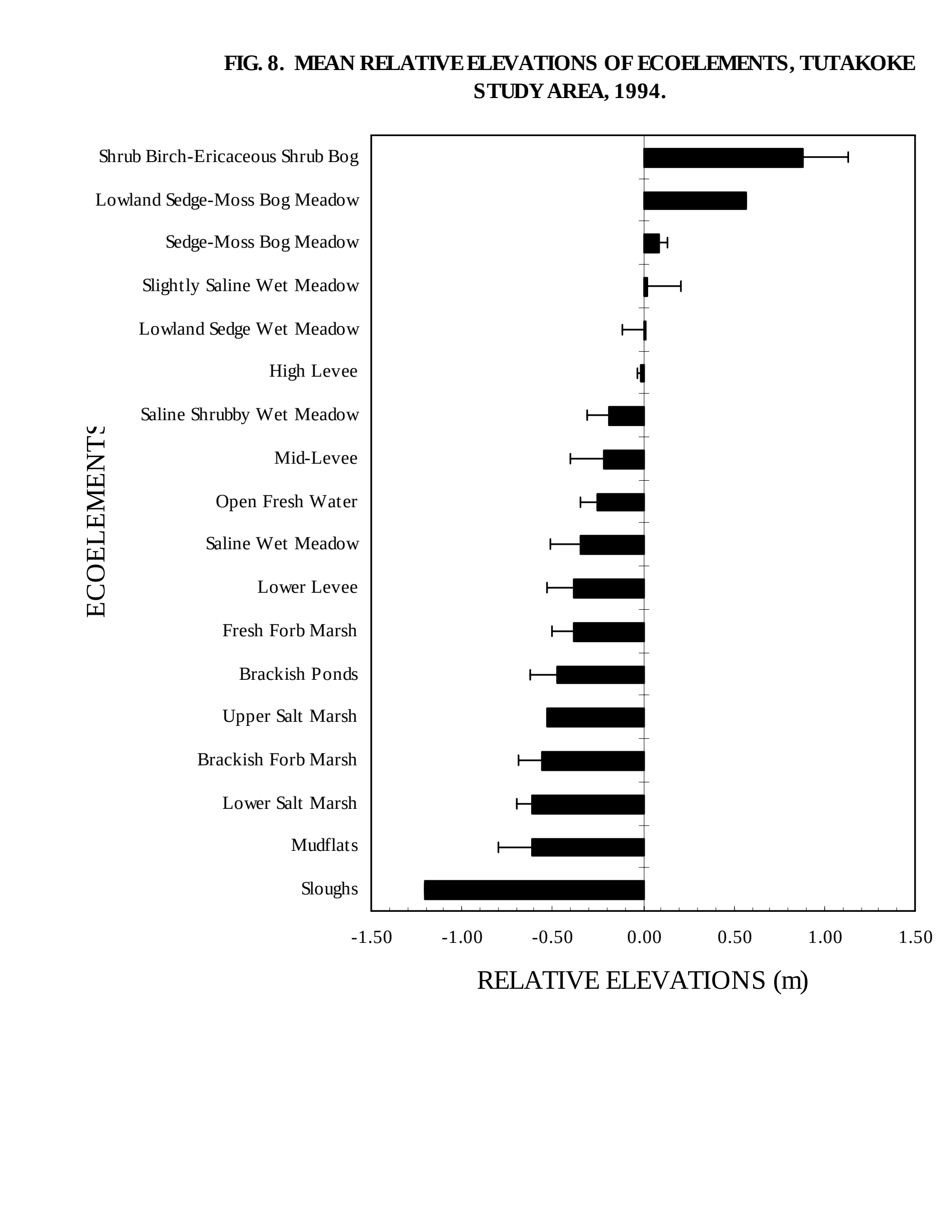


FIG. 8. MEAN RELATIVE ELEVATIONS OF ECOELEMENTS, TUTAKOKE STUDY AREA, 1994.
Shrub Birch-Ericaceous Shrub Bog
Lowland Sedge-Moss Bog Meadow
Sedge-Moss Bog Meadow
Slightly Saline Wet Meadow
Lowland Sedge Wet Meadow
High Levee
Saline Shrubby Wet Meadow
Mid-Levee
Open Fresh Water
Saline Wet Meadow
Lower Levee
Fresh Forb Marsh
Brackish Ponds
Upper Salt Marsh
Brackish Forb Marsh
Lower Salt Marsh
Mudflats
Sloughs
ECOELEMENTS
-1.50 -1.00 -0.50 0.00 0.50 1.00 1.50
RELATIVE ELEVATIONS (m)

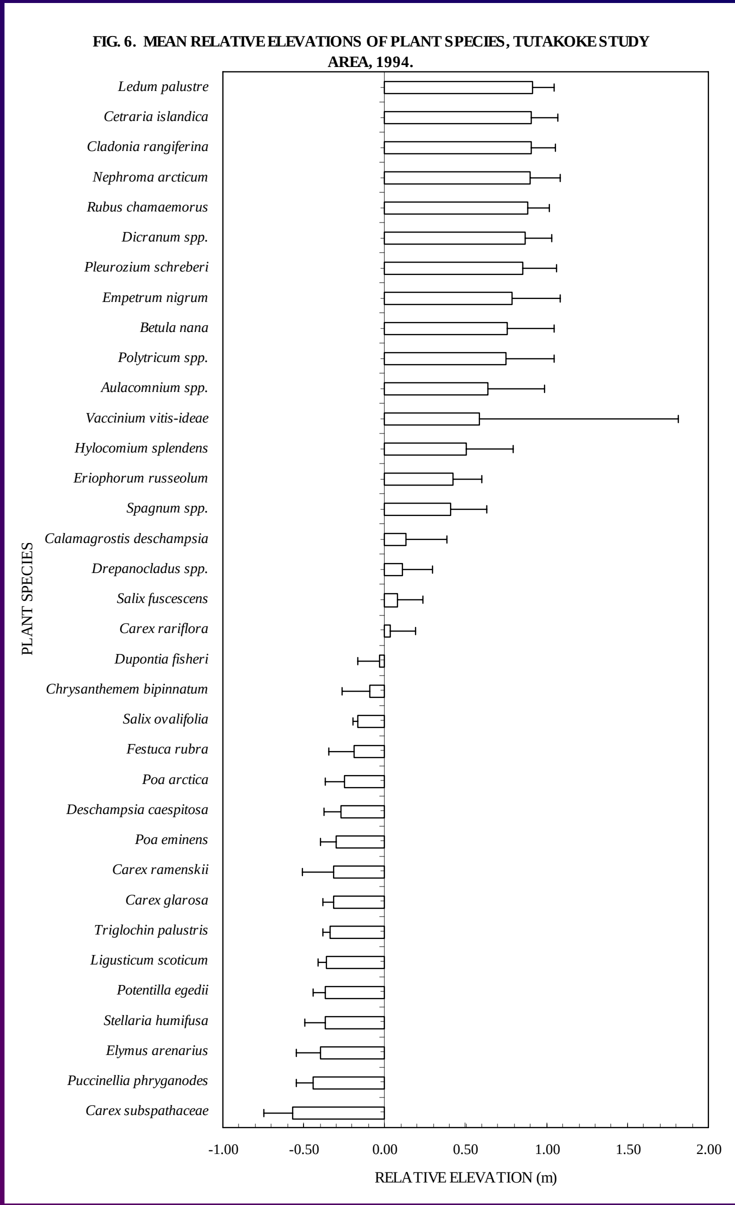
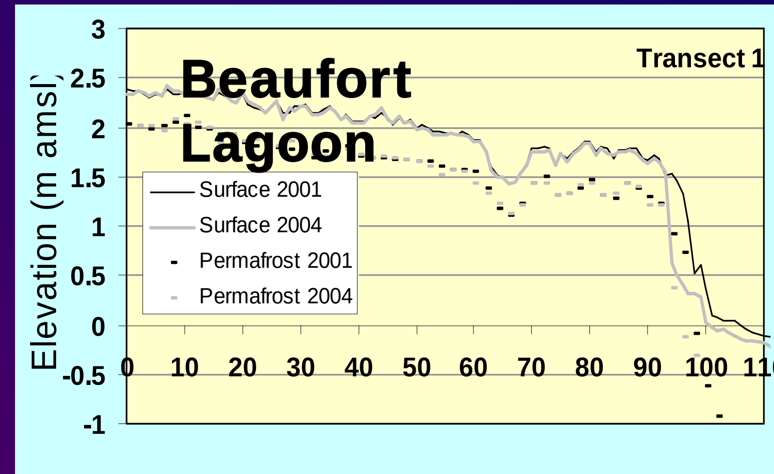


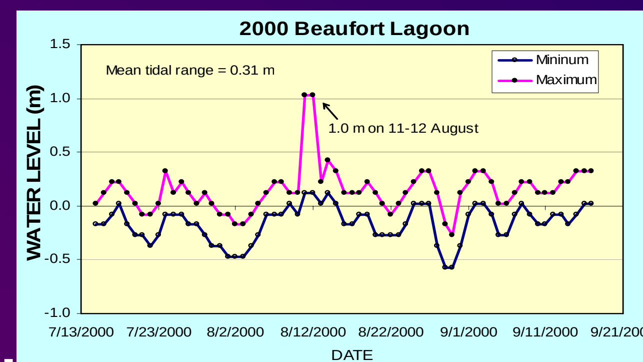
FIG. 6. MEAN RELATIVE ELEVATIONS OF PLANT SPECIES, TUTAKOKE STUDY AREA, 1994.
Ledum palustre
Cetraria islandica
Cladonia rangiferina
Nephroma arcticum
Rubus chamaemorus
Dicranum spp.
Pleurozium schreberi
Empetrum nigrum
Betula nana
Polytricum spp.
Aulacomnium spp.
Vaccinium vitis-ideae
Hylocomium splendens
Eriophorum russeolum
Spagnum spp.
Calamagrostis deschampsia
Drepanocladus spp.
Salix fuscescens
Carex rariflora
Dupontia fisheri
Chrysanthemem bipinnatum
Salix ovalifolia
Festuca rubra
Poa arctica
Deschampsia caespitosa
Poa eminens
Carex ramenskii
Carex glarosa
Triglochin palustris
Ligusticum scoticum
Potentilla egedii
Stellaria humifusa
Elymus arenarius
Puccinellia phryganodes
Carex subspathaceae
PLANT SPECIES
-1.00 -0.50 0.00 0.50 1.00 1.50 2.00
RELATIVE ELEVATION (m)

Topographic Surveying



Nuiqsut Field Workshop

Water-level Monitoring

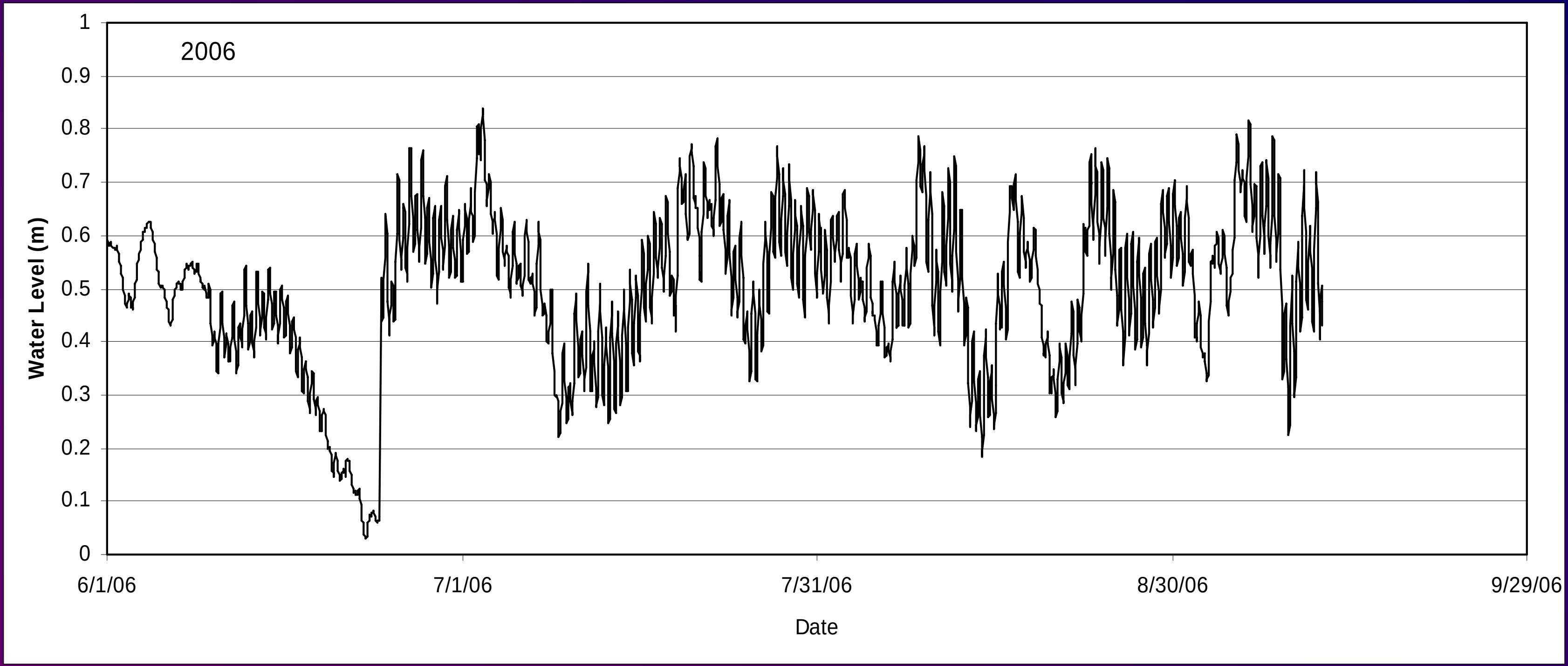


Discussion of crest gauges, Nuiqsut

HOBO Water Level Logger

Installation of submersible tide gauge, Barrow

Sedimentation


2006
Water Level (m)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6/1/06
7/1/06
7/31/06
8/30/06
9/29/06
Date

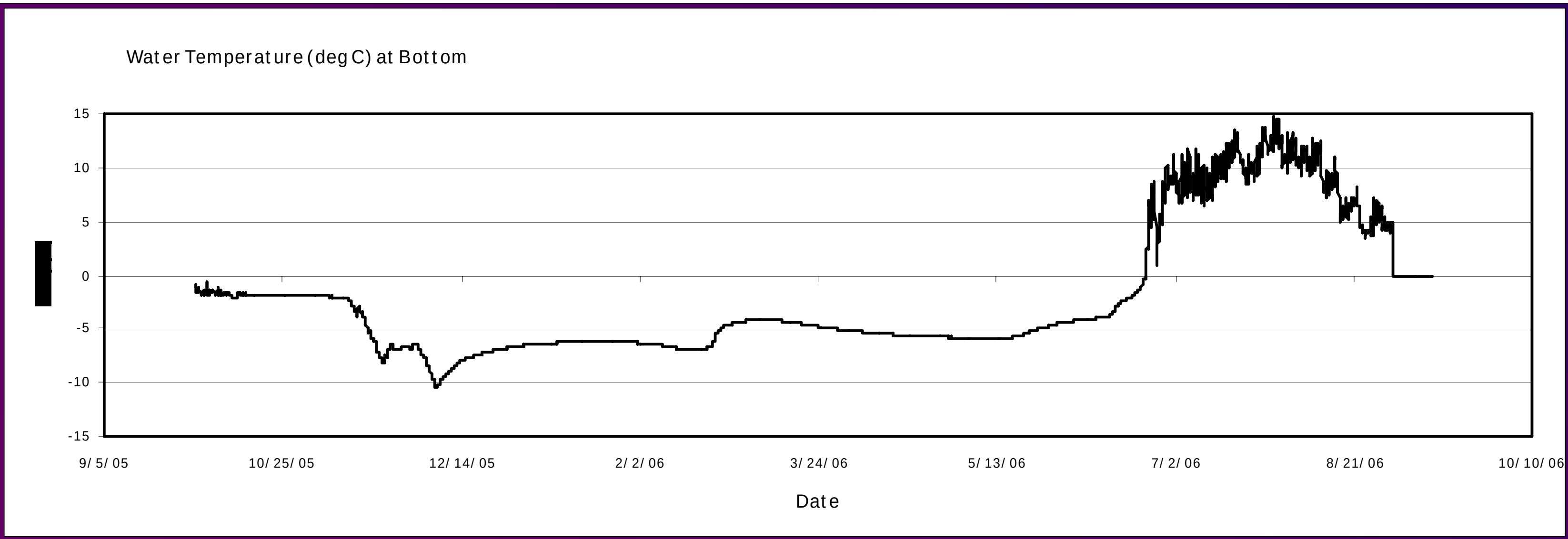
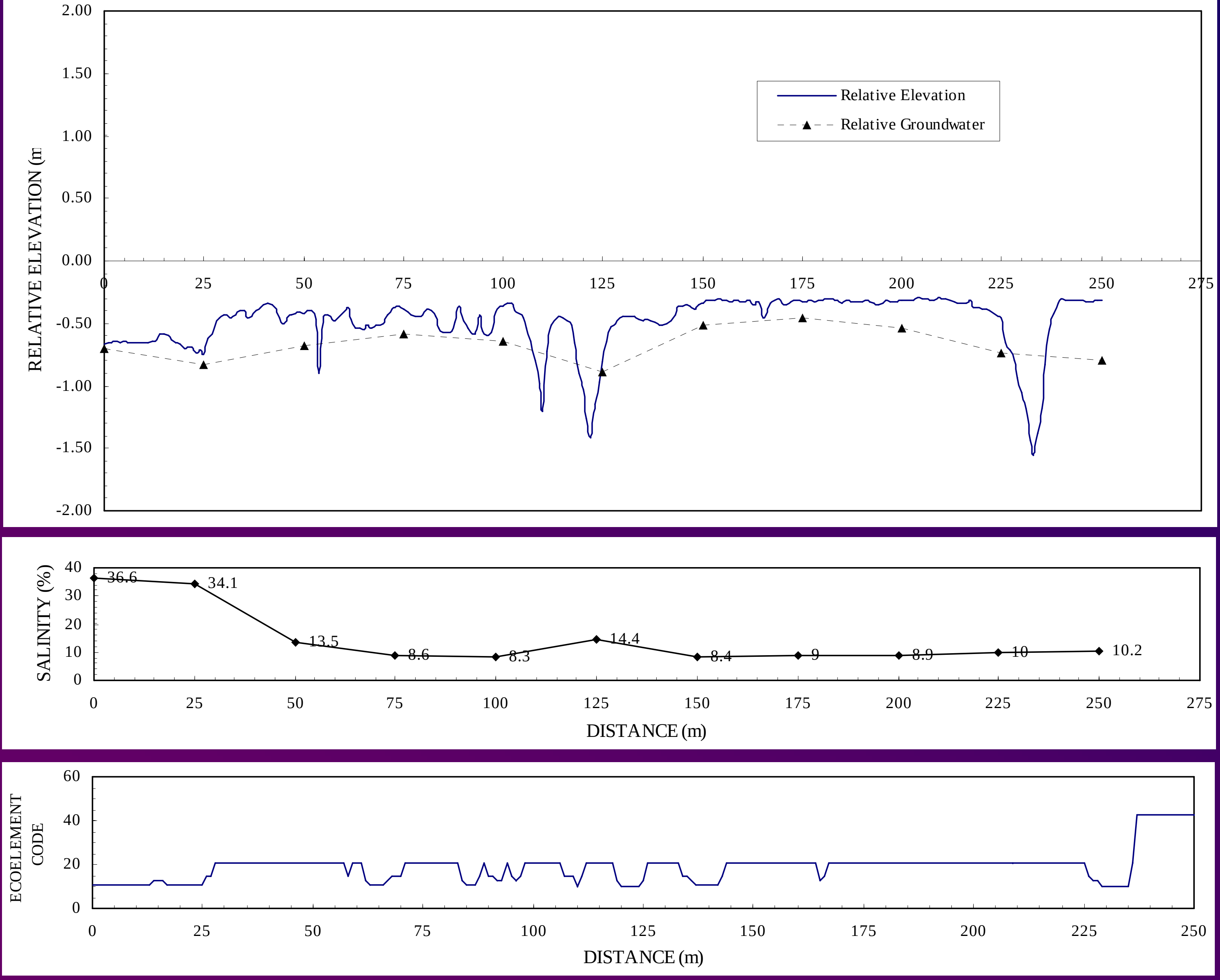

Water Temperature (deg C) at Bottom
15
10
5
0
-5
-10
-15
9/5/05
10/25/05
12/14/05
2/2/06
3/24/06
5/13/06
7/2/06
8/21/06
10/10/06
Date

FIG. 2. CROSS-SECTIONAL PROFILE FOR TRANSECT 1, TUTAKOKE STUDY AREA, 1994.



Schedule and Timeline

- *December 1, 2006:* Final study plan for protocol development due.
- *March 14, 2007:* Present a 20-minute overview/introduction of the protocol development project to the SWAN Technical committee.
- *May 15, 2007*: Report due on evaluation of historic and current imagery for landscape-level change, including delineations of salt marsh extent and changes in surface hydrology.
- *May 15, 2007*: Draft protocol narrative and SOPs due, including sampling design and field methods for topographic, ground and surface water, salinity, sedimentation, vegetation monitoring, photo point establishment, and manual interpretation of historic photos.
- *July 2007*: Field testing of methods.
- *November 1, 2007*: Revisions to draft protocol due, including power estimations for change detection and SOPs for data analysis and reporting.
- *November 23, 2007*: SWAN review returned to ABR.
- *December 15, 2007*: Final protocol and associated deliverables due.
- *December 31, 2007*: Annual Report and poster due.

Field Testing of Monitoring Protocols, 2007

- Two sites, Chinitna Bay and Silver Salmon
- Transects: surface elevations, community boundaries;
- Intensive plot, data will be collected on surface elevation (described above), ground and surface water levels and chemistry, sedimentation, and vegetation.
- Photo-trend plots: Each photo-trend plot will be marked with two small stakes 10-m apart. A photograph will be taken from each stake across the plot. In addition, the percent cover of the dominant 5–10 species will be estimated visually.